clouds around and about, and to the east of the fire, again made their appearance, while in every other quarter it was clear. Now, said I, to one of the company, 'If Espy's theory is worth anything, we should have a shower of rain.'

"The clouds now began to grow more massive, and repeatedly changed color, giving decided evidence of an approaching storm. In a few moments more the rain began to fall, first in large crystal drops in exact imitation of an evening sunshine shower, and then a heavy dash of rain descended, which wet us to the skin, and continued until the fire was extinguished.

"For weeks before there had not been a cloud to be seen, and at the time the rain was descending there were no clouds to be seen, except on the island in the immediate vicinity of the fire. Every place else was enveloped in clear, bright sunshine. The evidence that the rain was caused by the fire was unmistakable, for with the fire came the clouds, with the clouds, the rain; and when the fire was quenched by the rain, all was again brightness and sunshine.

"ABEL SHAWK."

FALLOW FIRE AND SHOWER IN NEW HAMPSHIRE.

"In July, 1856, I had occasion to cross this ridge [west of Keene, N. H.] and to pause on its summit to give a little rest to jaded animals. The weather was excessively hot. Not a cloud was to be seen, nor was there a breath of wind stirring. Looking to the southeast at a distance of some 5 or 6 miles, I saw a fire just kindled in a fallow of some acres extent. * * * Up went the column straight as an arrow, and anon it began to expand at the top and assume the appearance of cloud. This cloud, with its base stationary, expanded upward, and swelled as if a huge engine was below with its valve open for the escape of steam. The thin white cap appeared; the color changed, and soon the rain began to descend.

"It remained stationary for a few minutes, looming up higher and widening on either side a few minutes, and then sailed off in an eastern direction, pouring down torrents of rain in its pathway. I do not know the exact time occupied in this process, but I do not think more than half an hour elapsed between the kindling of the fire and the time the rain commenced falling. All this time at my point of observation the sun was shining brightly, and, besides that one over the fire, there was no cloud to be seen."

"J. D. WILLIAMSON,
"*Pastor of the First Universalist Church.*
"OCTOBER 30, 1856."

THUNDERSHOWERS FROM GRASS FIRES IN PARAGUAY.

"M. Dobrezhoffer, in his account of the Abiphones of Paraguay, volume 3, page 150, says: 'I, myself, have seen clouds and lightning produced from the smoke over the tall grass and bulrushes, as it is flying off like a whirlwind; so that the Indians are not to blame for setting fire to the plains in order to produce rain, they having learned that the thicker smoke turns into clouds, which pour forth water.'

"The bad philosophy of supposing that the smoke turned into cloud does not invalidate the evidence here furnished, that rain was produced by the fire." [1]

[1] Naegler (Das Wetter, Aug.-Sept., 1917, p. 179) reports the formation of a great cumulus over a fire on a nearly calm day at Kobilnik, Russia, June 21, 1917. About 4 km. from the fire large raindrops fell for 10 or 15 minutes. He mentions also the common formation of great cumulus clouds over the savanna fires during the dry season in tropical Africa.—EDIT.

VOLCANO RAINS.[2]

"Baron Humboldt gives, as an instance of what he calls the *mysterious* connection between volcanoes and rain, the fact that when a volcano breaks out in South America in the dry season, it turns it, while the volcano is in blast, into a rainy season.

"In his Views of Nature, page 366, speaking of Vesuvius in the last great eruption, he says: 'The long drought which had parched and desolated the fields before the eruption was succeeded toward the termination of the phenomenon by a continued and violent rain, occasioned by the *volcanic* storm which we have just described. A similar phenomenon characterizes the termination of an eruption in all zones of the earth. As the cone of cinders is usually wrapped in clouds at this period, and as the rain is poured forth with more violence near this portion of the volcano, streams of mud are generally observed to descend from the sides in all directions.' "

HEIGHTS OF CUMULUS CLOUDS FORMING OVER FIRES.

By S. P. FERGUSSON and C. F. BROOKS, Meteorologists.

[Dated: Weather Bureau, Washington, D. C., May 3, 1919.]

Apparently, very few measurements have been made of the height or movement of cumulus clouds over fires. The writers know of but six instances of the kind, and since they are of unusual interest to students it seems desirable to present a brief account of the formation and heights of these clouds.

The first example is a measurement made by A. E. Sweetland and S. P. Fergusson of two small cumulus clouds forming over a fire which destroyed the Bay State Iron Works, in South Boston, June 30, 1899.[1] On this date the weather was fair, the sky nearly cloudless in the afternoon, and the surface wind very light and from a westerly direction. The fire began shortly before 8 p. m. and the smoke-cloud was not of unusual size, but rose vertically to a considerable height (800 to 1,000 meters), encountering at this height a northwesterly wind, which swept it nearly horizontally over Boston Harbor. The smoke reached its greatest height about 8:05 p. m. At 8:03 p. m. a small white cloud began to form at the apex of the smoke, which at this time was nearly over Long Island, in the harbor. This cloud increased rapidly in height, assuming the form of a true cumulus, and reached its greatest dimensions at 8:05 p. m. It was about 3° in height and length, the highest or thickest end being toward the north. Between 8:05 and 8:07 p. m. another, smaller cloud formed at the eastern edge of a rift in the smoke considerably lower than the first and about 5° farther north. Mr. Sweetland, at Winthrop, 8 kilometers northeast of the fire, estimated the altitude of the higher cloud to be 15°, while a measurement with nephoscope by Mr. Fergusson at Blue Hill Observatory, 16 kilometers south of the fire, gave 10° as its altitude as seen from the observatory. These measurements show that the higher of the two clouds was at least 2,500 meters, while that of the lower was about 2,000 meters, above sea level.

The smoke began to diminish in quantity at 8:07 p. m. and separated from the clouds, which became flatter and more elongated. At 8:11 they separated from the smoke by a space several degrees wide, and after this time they slowly evaporated.

[1] Described, with sketch, in Science, July 21, 1899, p. 86.
[2] Cf. Hann's Lehrbuch d. Meteorologie, 3d ed., 1915, p. 692.—EDIT.

During the conditions prevailing on June 30—relatively dry air and clear sky—the level at which cumulus will form is higher than usual, but at or after sunset, when the fire occurred, the level where condensation in air rising from the surface would occur must have been considerably lower. At the Boston office of the Weather Bureau at 8 p. m. the temperature of the air was 19.7° C. and the dewpoint 6.7° C. Under forced ascent and adiabatic cooling, air with this temperature and dewpoint would become cloudy at about 1,700 meters above sea level [$H_m = (t_a - t_{dp})/.0077$]. Therefore, it appears that the fire caused clouds to form some 300 to 800 meters higher than might otherwise have been the case.

The next instance occurred on April 12, 1908, during the great conflagration in Chelsea, Mass., when more than 2 square miles of city blocks were consumed. The fire began about 11 a. m. and the clouds formed between 2 and 3 p. m., when the column of heated air was at its maximum extent.

The sky was cloudless, the temperature in the afternoon was 7°C. (or below normal), the relative humidity was very low—14 per cent—and a strong gale blew from the north-northwest. The column of smoke was of immense size, and at its highest point, situated over Boston Harbor some 19 kilometers from Chelsea there formed a succession of flat, white cumulus clouds, which after drifting farther to leeward, slowly dissolved as they sank into a warmer stratum, because no longer supported by the rising column of heated air.

Approximate angular measurements, made at Blue Hill Observatory by Mr. L. A. Wells and in Boston by Prof. A. L. Rotch, gave the minimum height of these clouds between 4 and 5 miles (average, 7,200 meters). Their relative velocity, compared with the surface wind, also indicated that they were much higher than the ordinary cumuli which float at the level of about a mile (1,609 meters). Mr. Fergusson discussed these observations with Prof. Rotch at the time, and although the altitudes were estimated, both observers were accustomed to making such estimates; and while almost all estimates of altitudes are too high, it does not seem likely that the height given is more than 1,000 meters too great. During the conditions prevailing on the afternoon of April 12, 1908, the potential height of the bases of cumulus clouds, computed from the depression of the dewpoint, was about 3,500 meters. Hence, we have in this a good example of a cloud forming artificially at nearly twice the height it should form under natural conditions.

This cloud was described by Prof. Rotch in Science, May 15, 1908, pages 783–784.

A third example occurred on October 21, 1908, when the column of heated air was not of itself sufficient to form clouds of appreciable size, but caused a rapid increase in dimensions of small fracto-cumuli drifting over the fire. On this occasion a large barn about 2 kilometers east of Blue Hill Observatory was consumed. The contents, chiefly hay and straw, burned with great intensity, the flames rising 30 meters above the building. The fire began at 1:15 p. m. and reached its maximum intensity at about 1:45 p. m. On this date the temperature was below normal and a moist sea breeze of about 7 m./s. was blowing from the northeast. A few small fracto-cumulus clouds were floating in this wind at a height, determined by observations of their shadows, of about 1,000 meters. The observations and sketch (fig. 1) given were made at the time by Mr. Fergusson.

At 1:20 p. m. a few distinct nuclei were observed in the upper surface of the smoke cloud and between this time and 1:50 p. m. the number varied from one or two to more than 10. At 1:35 p. m. a small patch of fracto-cumulus on drifting into the smoke rapidly increased in density, a shell of cloud forming outside the original cloud, and which slowly united with it. At 1:40 p. m. the small cloud was double its original size, after which it diminished, disappearing at 1:55 p. m. The height of this cloud, observed by means of a transit, was about 1,100 meters, or slightly higher than the clouds in the free air at a distance from the fire.

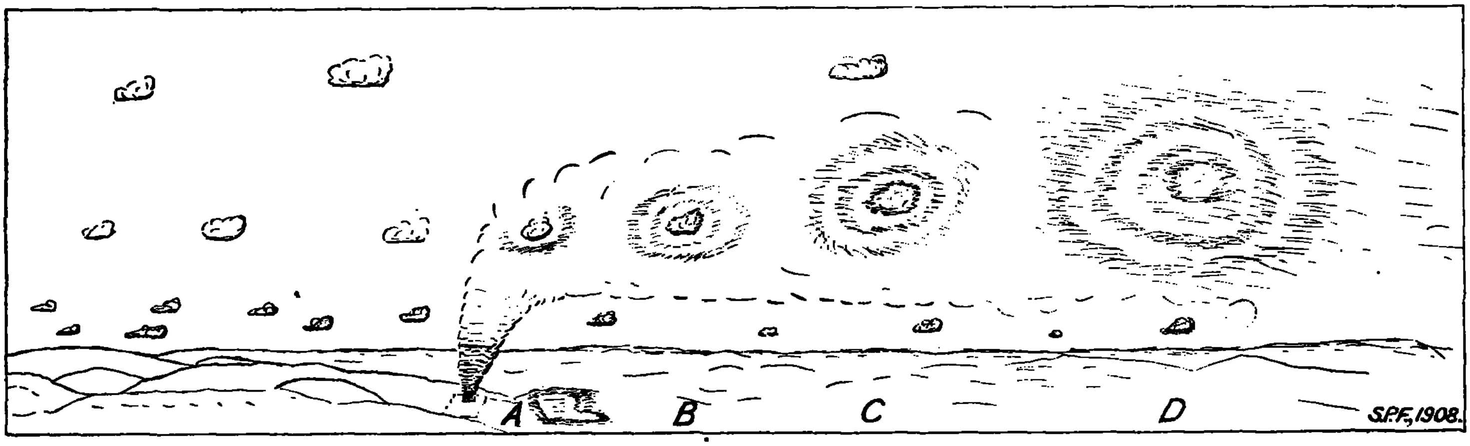

FIG. 1.—Growth of cumulus clouds in heated air over fire, Milton, Mass., Oct. 21, 1908. A, 1:35 p. m.; B, 1:40 p. m.; C, 1:42 p. m.; D, 1:45 p. m.

In figure 1 the successive appearances of the small cloud in the heated air column are indicated by A, B, C, and D.

The fourth example also was obtained at Blue Hill Observatory, by C. F. Brooks on July 22, 1913, when a large cumulus formed over a burning fertilizer factory in Weymouth, 16 kilometers east-northeast of the observatory. The fire began at 3:35 p. m. and the smoke cloud reached its maximum intensity at 3:47 p. m., rising at an apparent angle of 33° to 38°. The cumulus cloud appeared at 4 p. m. and disappeared at 5 p. m. Photographs were made at 4, 4:03, and 4:15 p. m. The following observations were made with a transit:

	Summit of cloud.		Southern edge.
Time	4:25 p. m.	4:35 p. m.	4:35 p. m.
Altitude	5.4°	4.6°	3.1°.
Azimuth	250.5°	248.5°	261°.
Probable distance of cloud	17 kilometers.	18 kilometers.	18 kilometers.
Height above sea level	1,800 meters.	1,700 meters.	1,200 meters.

Azimuth of fire, 254°; direction and velocity of wind, S. (360°), 7 m./s.

The temperature at Blue Hill was about 25° C. At 8 p. m. it was 18.9°, the dew point 16.7°, and the maximum of the day 28.3° C. Therefore, the height of the potential cumulus base was about 1,000 m. above Blue Hill, or 1,200 m. above sea level. Thus, the fire-formed cloud seems to have been but little, if any, higher than the elevation at which clouds would have formed naturally.

The fifth example was observed at Lindenburg, Germany, on July 29, 1917, by Dr. H. Hergesell, and a description with a photograph was published by him in Das Wetter, August–September, 1917, pages 178–179. On that date a large forest fire occurred and the smoke cloud, mounting to 1,255 meters, became limited, for the most part, by an inversion of temperature (observed by kites at 1,000–1,200 meters). Over the hottest part of the fire, however, the upcurrent was warm enough, with the aid of the latent heat from condensation, to push through this limiting inversion layer and to form a cumulus cloud with an apex rising to 1,800 meters.

The last example is that given by Mr. Reichelt on page 144 of this issue of the REVIEW. The height of the base of the cloud observed was about 1,500 feet and that of the top 2,500 feet (approximately 450 and 750 meters, respectively). From the data as to temperature and humidity given, the height of the potential base of cumulus clouds at that time was 750–850 meters. Thus it seems that the moisture contained in the burning leaves added so much humidity to the air that even at the high temperature of the rising column, condensation took place appreciably lower than would have resulted from fireless convection.

From these examples, it appears that the height at which cumulus clouds will form over fires depends largely on the dryness of the hot air ascending from the fire; and, therefore, that the height of the cloud base is generally greater over burning buildings than the height of the potential base if there were normal convection, but less over burning leaves or other material containing much water.

RESULTS OF OBSERVATIONS OF CLOUDS DURING THE SOLAR ECLIPSE JUNE 8, 1918.

By S. P. FERGUSSON, Meteorologist.

[Dated: Weather Bureau, Washington, D. C., May 3, 1919.]

Observations of the kind, amount, direction (azimuth), relative velocity, and position of clouds were received from 17 stations equipped with nephoscopes and located within or near the zone of 90 per cent totality: also, there are available at these and other stations, notes concerning changes in appearance of clouds, unusual phenomena, etc. At two stations nephoscopes were improvised by the observers, and at a third azimuths were observed by means of a compass.

Observations of azimuth, etc., were made every half hour from noon local standard time until the last regular observation of the day, except during the period beginning an hour before and ending an hour after totality, when they were made every 10 minutes.

Table 1 contains all the data of azimuth and relative velocity of clouds observed continuously during the eclipse, excepting those at stations reporting severe thunderstorms and stations where no change of condition was observed. The data from the latter are referred to in the notes accompanying the table.

In figure 1 the actual observations of azimuth, as made, are plotted with reference to the position of the shadow according to the method employed in the study of the winds and described in the REVIEW for January, 1919, **47**: 12–13. The data are given for each 10-minute interval before and after totality.

As in the instance of the wind at the earth's surface, it is to be expected that the direction of motion of the lower clouds, and perhaps, under extremely favorable circumstances, that of the upper clouds, will be affected by the eclipse-shadow. However, since the mean velocity of the wind in which the clouds float is higher than that of the surface wind, the influence of the shadow will be definitely measurable only when the velocities of the upper air are relatively slow or below normal. In the instance of the lower clouds accurate measures of the direction often are difficult to obtain, particularly when the conditions are favorable for local storms and the complex movements, horizontal and vertical, of parts of the same cloud are likely to be confused with the general drift of the air. In one important respect observations of clouds are of greater value than records of wind at the surface; they indicate motions of the free air uninfluenced by local topography (mountains, buildings, etc.).

As stated in the discussion of the winds recorded during the eclipse, the meteorological conditions generally near the shadow-path, were unfavorable for this study because of thunderstorms and other local phenomena, and for this reason many of the records of cloud observations could not be used. One very favorable circumstance was that the velocities of clouds in nearly all instances were unusually low.

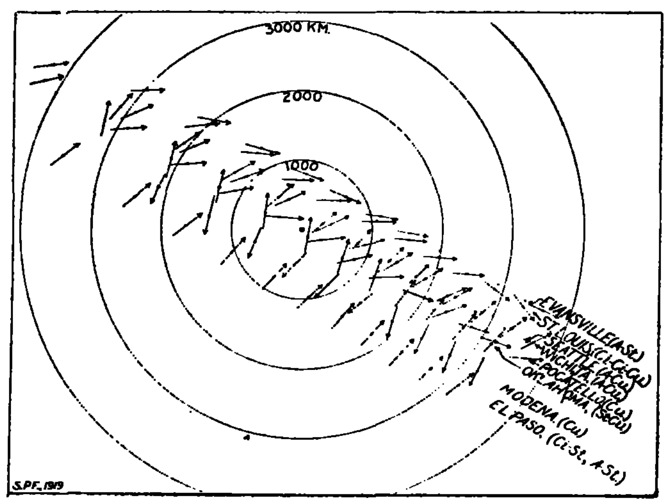

FIG. 1.—Changes in the directions of clouds during the solar eclipse, June 8, 1919.

No data of diurnal variations of the direction and relative velocity of clouds are available for the United States except in New England. Averages of hourly observations at Blue Hill Observatory show that the direction of the upper clouds tends to become more westerly in the early afternoon and return to the original point toward evening. For example, clouds moving from azimuth 130° at 10 a. m. would very probably change to 110° at 1 p. m. and back to 130° by 6 p. m. It is reasonable to suppose that the same kinds of clouds follow the same general law, at least approximately, at stations in other parts of this country; but, in view of the facts that these diurnal periods are small and that unusual conditions prevailed on June 8, it is considered inadvisable to attempt to apply corrections. The average duration of the eclipse at any station was about two hours and the difference